Review of Crimes in Peru and Proposal of a Neural Network Architecture to Predict if a Person Could Commit a Crime

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***Abstract*-Citizen insecurity is one of the most important problems in our society. We have reviewed the investigations that predict crimes with different techniques. Due to this, in this research we propose an architecture of a neural network capable of predicting the possible crimes that a person could commit, after answering a form about their family and social conditions. In this research, three architectures have been tested to look for the improved architecture of the neural network that predicts the crimes. We conducted the experiment using data from the 2016 Peruvian National Penitentiary Census, which consists of 14,000 records. We concluded that the neural network architecture with 24 input neurons, 21 neurons in the first hidden layer, 21 neurons in the second hidden layer and 19 neurons in the output layer is the most recommended for predicting crimes with a mean square error of 0.278100. Validating with 14000 records, an accuracy of 96.03% has been obtained, finally a web application has been implemented as a tool for the institutions that administer and punish crimes.**

I. INTRODUCTION

Citizen insecurity has proven to be the focus of the concern of the citizens and the Peruvian State [1]. This concern is a consequence of the high crime rate in the country. The revised numbers support the anguish and mistrust that citizens feel daily.

We have that, currently, Peru is the country with the second highest rate of insecurity, and this can be seen in the results of the latest edition of the America's Barometer 2017, where 33% of respondents said they had been victims of a criminal act such as theft, robbery or extortion in the last 12 months [2]. On the other hand, the Instituto Nacional de Estadística e Informática (INEI) indicated that in the semester of November 2017 and April 2018, 25.5% of the population aged 15 and over had been victims of some criminal act. In the analysis carried out, it was found that more men than women reported having been victims of a crime, 25.7%, and 25.3% respectively. [3]. The number of criminal incidents reported monthly is alarming because of its rapid rise, for example, only in January 2018, 19,697 crimes had been reported, of which 8,382 were thefts (42.5%). These data do not include acts that are not reported in police stations [2]. The citizens' concern, too, is linked to other crimes, including femicide, which has presented an increase of 26.4% since January and April 2017 regarding the same period in 2018 [4].

Another fact observed was that many of the reported cases of crimes involved the use of weapons. The activities that are carried out with these weapons represent a type of risk for Peruvian society [5]. We have, for example, that between 2016 and 2017, at the national level, the number of firearms crimes increased from 7% to 10% [6]. Many people pay a sentence as consequence of having committed some crime related to the illegal possession of weapons, as reflected in the INPE information obtained that served as an input for what this investigation covered.

Among the leading causes of the mentioned crimes (and others) are poverty, inequality, unemployment, among others [5]. And although there is a National Citizen Security Plan for the period 2013-2018, in which 6 strategic objectives were proposed to face insecurity, violence, and crime, there is distrust on the part of the citizens towards the authorities due to the climate generated by the omission of faults, armed crimes, and other crimes.

It can be observed, too, that for 2017, 1,189,332 Peruvians mentioned having tried marijuana once in their lives, and of these [7] There is a relationship between drug use and juvenile delinquency, supported by the results of the "Differentiated Juvenile Justice" investigation conducted by the Ministry of Justice in partnership with the United Nations Joint Human Security Program, which indicate that the 80 % of juvenile delinquents consume alcohol and 59% consume drugs [8].

Another critical factor in the profile of criminals in Peru is the family condition and the environment in which they grew up. This ranges from the moral education provided in the home to the educational level they could reach. The lack of a proper moral education in homes affects minors and can harm them in training for the rest of their lives. [9].

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Artificial intelligence techniques are applied to solve different problems, as well as we can analyze the detection of heart diseases with neural networks [23], they analyze the presence of tuberculosis with image processing [27], information retrieval [24], augmented reality [25], routing questions and answers with neural networks [26], recommendation of video games with fuzzy logic [28], neural networks and support vector machine to classify basal cell carcinoma [29], among other applications. Likewise, in other investigations they apply different algorithms in the prediction and analysis of crimes or crimes.

Several previously developed techniques have been applied over the years to analyze information and find patterns in different areas of study. Some of these techniques have been used: Machine Learning to calculate the suicidal tendency in young people [22], Data mining for the analysis of criminal behavior [13], Neural Networks [15] for the prediction of crimes, among others. Being the last mentioned, the technique chosen for this investigation.

With the identified problem and the chosen technique, the objective was to predict the crimes that could be committed by someone based on their personal information; using a neural network trained with the data obtained from criminals held in penitentiaries in Peru. The initial idea was conceived under the premise of prevention rather than punishing since several studies [5], [7], [8], [9] have shown a relationship between the personal information of criminals and their respective crime committed.

In this research, three architectures of neural networks are designed to find the one that best predicts the crimes. After presenting the best architecture, an application is designed to predict the crime as a usable tool for the institutions that administer the crimes.

II. Overview of Crime Predictions

Crimes influence organizations and institutions when they occur frequently in a society. Therefore, it is necessary to study the reasons, factors, and relationships between the occurrence of different crimes and find the most appropriate ways to control them and avoid more crimes. Several authors have addressed this problem using artificial intelligence techniques and data science.

In 2014, research [11] was developed using a set of crime data to predict the "category of crime" for various states of the United States of America (USA). The data used were of a real nature and were compiled from socioeconomic data from the 1990 United States census. This document made a comparison between two different classification algorithms: Naive Bayes Classifier and Backpropagation (BP). The results of the analysis showed that the Naive Bayes Classifier exceeded the BP algorithm and reached an accuracy of 90.2207% for the first group of data and 94.0822% for the second.

On the other hand, in 2015 [12] sought to classify crimes by grouping them according to the frequency in which they occur over the years. The authors proposed a theoretical model based on data mining techniques such as clustering and classification, to a set of real crime data recorded by the police in England and Wales between 1990 and 2011. Besides, a genetic algorithm (GA) was used to optimize the parameters of the operator of a detection of outliers using the RapidMiner tool. The results of the article concluded that the model was adequate for the classification of crimes, however, the need to optimize the number of clusters in the grouping process and improve the technique used in the prediction phase was also highlighted.

Another investigation that applies data mining techniques was [13], in 2016. It proposed a method for the analysis of criminal behavior. The technologies used for the development of this article were the K-means clustering algorithm and the genetic algorithms. Making use of genetic algorithms, the author managed to obtain the optimal initial center; Then, he used the K-means algorithm to a group and obtain the optimal grouping results.

Research [14] provided a framework for intelligent prediction and detection of crime patterns. The data used for the development of this research consisted of 431 tuples with 31 key columns. To make the classification of states, random forests were used in Rapid Miner. Finally, the Support Vector Machine algorithm was used to predict the degree of crime in a specific state.

Taking advantage of this, [15] presented CRIMECAST: a crime prediction and strategy management service that attempted to predict probable future crimes through simulation. To implement it, it was necessary to create a probabilistic model and an artificial neural network. In 2017, [16] reviewed the primary methods used to predict crimes, among the methods mentioned are the SVM algorithms, fuzzy logic, neural networks, and multivariable time series. Later, [17] explored models to predict the frequency of various types of crimes by LSOA code (Lower Layer Super Output Areas, an administrative system of geographic areas used by the UK police) and the frequency of antisocial behavior crimes. Three algorithms from different categories of approaches were used: instance-based learning, regression analysis, and decision trees. The data used was obtained from the UK police and contained more than 600,000 records before preprocessing.

In research [18], the main objective was the generation of knowledge to help increase the effectiveness in the prediction of crime in India, using online statistical information; and serve as support for police stations. Using the tools mentioned above, the dataset was subjected to 4 algorithms: Association Mining (a priori algorithm used to find frequent element sets), Clustering (grouped into two clusters using k-means), Classification Techniques (using the Naive Bayes algorithm). for a classification according to age); and, finally, Correlation and Regression.

Following the geographic data study approach of [17], research [19] developed a solution for the prediction of crimes for large cities in Chile. The objective of the predictive software system was to produce, for each municipality and for each shift, a map representing the areas

where crimes are most likely to occur while maintaining the number of areas represented as low as possible.

The performance of the system formed by the three modules was tested with historical data that were provided by the Criminal Analysis Department of Carabineros de Chile, and the following numbers were obtained as a result: The prediction of the crime was placed over 35%, and in many cases, above 50%, being 45.29% of the average value. An interesting result is that the performance of each individual module was lower than the joint performance, validating the hypothesis that different algorithms can exploit different characteristics of the available data.

In 2018, [20] used a set of data mining algorithms and ensemble learning applied in data analysis and crime prediction. The central objective of this document was to analyze and discuss several methods that are applied in predicting crime analysis.

Others researchers reviewed and mentioned in this chapter, it can be commented that [11], [16] and [20] sought to analyze and compare certain types of algorithms, methodologies or techniques used for the classification, analysis and prediction of crimes. While [12], [13], [14], [15] [17], [18] and [19] apply some of the techniques evaluated in the first three articles mentioned in this paragraph.

Nevertheless, these last 7 investigations also differ in the approach that each one gives to perform training and prediction. For example, [12], [13] based their research on grouping data under certain parameters. The investigations [14], [18] were based on the identification of patterns implementing algorithms of data analysis. Finally, in [15], [17] and [19] they sought to predict crime by simulation, decision trees and other algorithms used for training and prediction.

However, if we compare the two previously mentioned groups, it is observed that the investigation [20] and [18] considered that a prediction in a district within a specific period and season could help stop the crime or, at least, reduce it.

And the obstacle with the greatest presence, above all, in [14], [15], [18] was obtaining data. Although in some cases the information was obtained with relative ease, the problem was that this data always had certain deficiencies that, if they had been corrected, could have improved the results of the investigations. However, the results obtained are not demerited.

III. NEURAL NETWORK ARCHITECTURE DESIGN

The purpose of this research was to develop a neural network capable of predicting the possible crimes that a person could commit, after answering a form about their family and social conditions. To achieve this goal a multilayer neural network was designed, and the backpropagation algorithm was used.

A. Data extraction

The Instituto Nacional de Estadística e Informática - INEI, in coordination with the Ministry of Justice and the National Penitentiary Institute, carried out the First National Penitentiary Census, the objective of which was to obtain statistical information on the characteristics sociodemographic and legal situation of the prison population aged 18 years and over incarcerated in the 66 penitentiary establishments of the country. They proposed the questionnaire to carry out the census, the results were published on the INEI web portal [22] https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1364/libro.pdf, to design the architecture has been used 23 entries selected from the survey raised in the National Penitentiary Census.

TABLE I. NEURAL NETWORK INPUS

Field Name	Description	Value
P1	Gender	1: Man 2: Woman
P2	Civil status	1: Living Together 2: Married 3: Widowed 4: Divorced 5: Separated 6: Single
P3	Religion	1: Catholic 2: Evangelical 3: Mormon 4: Adventist 5: Jehovah's Witness 6: Other 7: None
P4	Age	Integer between 18 to 100
P5	Knowledge	1: Without level 2: Initial education 3: Incomplete primary 4: Complete primary 5: Incomplete secondary 6: Full secondary 7: Superior non-university incomplete 8: Superior non-university full 9: Incomplete university superior 10: Full university superior 11: Postgraduate
P6	During your studies, did you interact with classmates who had problems with the law?	1: Yes 2: No 0: Do not know / Do not answer
P7	Do you consume drugs?	1: Yes 2: No 3: Do not answer
P8	Do you drink alcoholic drinks?	1: Yes 2: No 3: Do not answer
P9	Do you smoke cigarettes?	1: Yes 2: No 3: Do not answer
P10	Have you ever worked?	1: Yes 2: No
P11	What is your occupation or job?	1: Employer? 2: Dependent worker? 3: Employee? 4: Worker? 5: Unpaid family worker? 6: Domestic worker?

Field Name	Description	Value
		7: Another one? 0: Default value
P12	What is the main reason why you have not worked?	1: Lack of studies 2: Health problems 3: Having a criminal 4: Family responsibilities 5: I was studying 6: I did not need to work 0: No job opportunity
P13	How old did you live with your mom?	Integer numbers between 10 to 120, 0 is the default value.
P14	How old did he live with his dad?	Integer numbers between 10 to 120, 0 is the default value.
P15	When you were a child (from 5 to 12 years old). Did any of your parents or the people who assumed that role hit you?	1: Yes, always 2: Yes, sometimes 3: No 4: Do not answer
P16	When you were a child (5 to 12 years old), did your parents or the adults who lived with you drink alcohol / liquor frequently?	1: Yes 2: No 3: Do not know / Do not answer
P17	When you were a child (5 to 12 years old), did your parents or the adults who lived with you use drugs?	1: Yes 2: No 3: Do not know / Do not answer
P18	Was your mom beat by your dad?	1: Yes 2: No 3: Null 4: Do not know / Do not answer
P19	Has any member of your family ever been imprisoned in a correctional facility?	1: Yes 2: No 3: Do not remember/ Do not answer
P20	Before turning 18, did any of your best friends commit crimes?	1: Yes 2: No 3: Do not remember/ Do not answer
P21	Were there any gangs or criminal gangs in the neighborhood where you lived before you were 18?	1: Yes 2: No 3: Do not remember/ Do not answer
P22	Do you have children?	1: Yes 2: No
P23	Have you ever felt discriminated against somewhere?	1: Yes 2: No

B. Artificial Neural Network Training

To fulfill the purpose of the research, the multilayer perceptron was selected, which is a one-way network (feedforward). The architecture of this network is represented in Fig. 1.

The neurons of the hidden layer use the weighted sum of the inputs with the synaptic weights (w_{ij}) as the propagation rule, and a logarithmic sigmoid transfer function is applied to that weighted sum. The formula for this function is shown below.

$$f(x) = \frac{1}{1+e^{-x}}$$

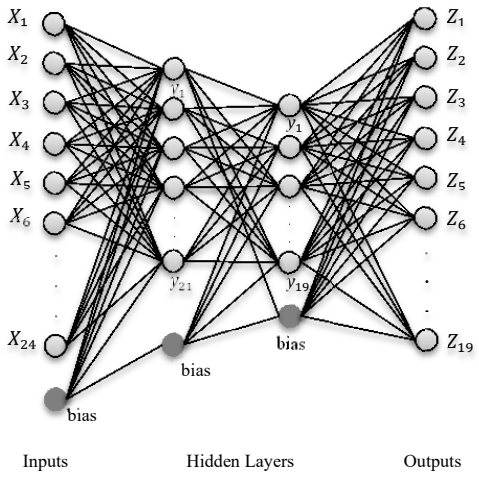

Fig. 1. Network architecture

The learning that was used receives the name of backpropagation of the error (backpropagation).

$$E_{(w_{ij},\theta_j,w'_{kj},\theta'_k)} = \frac{1}{2}\sum_p\sum_k\left[d_k^p - f(\sum_j w'_{kj}y_j^p - \theta'_k)\right]^2$$

Where dk are the desired outputs; f, the activation function; w_k, the synaptic weights.

A gradient decrease is applied to this global cost function. The expressions that result applying the rule of the chain are the following:

$$\delta_{w'_{kj}} = -\epsilon\frac{\partial E}{\partial w'_{kj}}$$

$$\delta_{w'_{ji}} = -\epsilon\frac{\partial E}{\partial w'_{ji}}$$

$$\delta_{w'_{kj}} = \epsilon\sum_p \Delta_k'^p y_j^p \quad con \quad \Delta_k'^p = \left[d_k^p - f(v_k'^p)\right]\frac{\partial f(v_k'^p)}{\partial v_k^p}$$

$$\delta_{w_{ij}} = \epsilon\sum_p \Delta_j^p x_i^p \quad con \quad \Delta_j^p = \left(\sum_k \Delta_k'^p w'_{kj}\right)\frac{\partial f(v_k'^p)}{\partial v_k^p}$$

Where w_k are the synaptic weights that are between the hidden layer and the outputs; ϵ, the learning rate; w_j, the weights that are between the entrances and the hidden layer; E, the output of the feedforward phase (forward propagation); w_j, the outputs of the hidden layer; and, finally, x_i, the entry patterns.

C. Crime prediction

To test the training of the neural network, two projects will be developed, which will consist of a web client and an interface associated with a non-relational database. The architecture of the application is represented in Fig. 2.

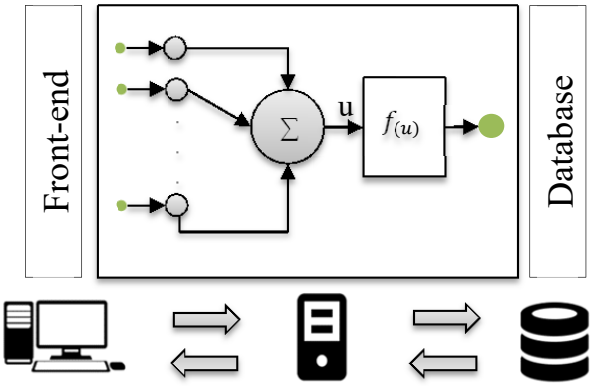

Fig. 2. Crime Predictor Architecture

D. *Interpretation of the outputs*

After performing the training, the output layer of the neural network will result in the probability that a person commits a crime. This layer is composed of 19 neurons, where each emits an output that represents a class of crime. TABLE II details the meaning of the outputs of the neural network.

TABLE II. NEURAL NETWORK OUTPUS

Field Name	Description	Value
DEL_1	Customs Crimes	1: Yes 0: No
DEL_2	Environmental Crimes	1: Yes 0: No
DEL_3	Crimes against the state and national defense	1: Yes 0: No
DEL_4	Crimes against honor	1: Yes 0: No
DEL_5	Crimes against the financial and monetary order	1: Yes 0: No
DEL_6	Offenses against property	1: Yes 0: No
DEL_7	Crimes against public administration	1: Yes 0: No
DEL_8	Crimes against trust and good faith in business	1: Yes 0: No
DEL_9	Crimes against the family	1: Yes 0: No
DEL_10	Crimes against public faith	1: Yes 0: No
DEL_11	Crimes against humanity	1: Yes 0: No
DEL_12	Crimes against freedom	1: Yes 0: No
DEL_13	Crimes against public safety	1: Yes 0: No
DEL_14	Crimes against public tranquility	1: Yes 0: No
DEL_15	Crimes against life, body and health	1: Yes 0: No
DEL_17	Crimes against the powers of the state and the constitutional order	1: Yes 0: No
DEL_18	Tax crimes	1: Yes 0: No
DEL_19	Money laundering	1: Yes 0: No

IV. DESIGN AND CONSTRUCTION OF THE APPLICATION

To test the training of the neural network, a software application was developed consisting of a web client and a server-side interface associated with a non-relational database. The objective of this application is to present an online questionnaire, composed of questions about the social and family conditions of the user. From their answers, the application predicts the type of crimes that the user is more likely to commit.

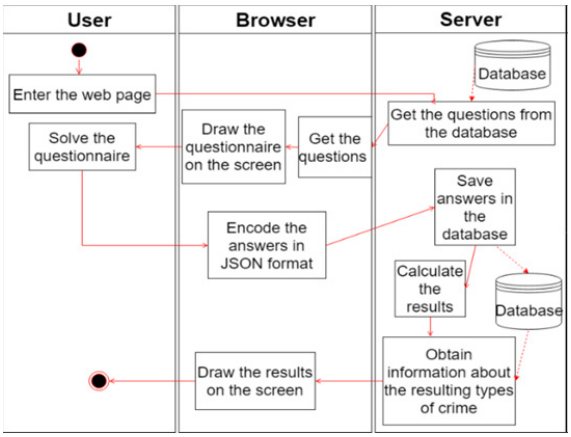

Fig. 3. System flow

Fig. 3 represents the general flow of the system through an activity diagram in UML notation.

A client / server architecture based on RESTful services was used to implement the solution.

The use of the REST protocol allows to separate the user interface of the server and the storage of data. This gives important advantages in the development: improves the portability of the interface to other types of platforms, increases the scalability of the project and allows the different components of the developments to evolve independently.

Fig. 4 represents the general architecture of the application and the technologies chosen for development.

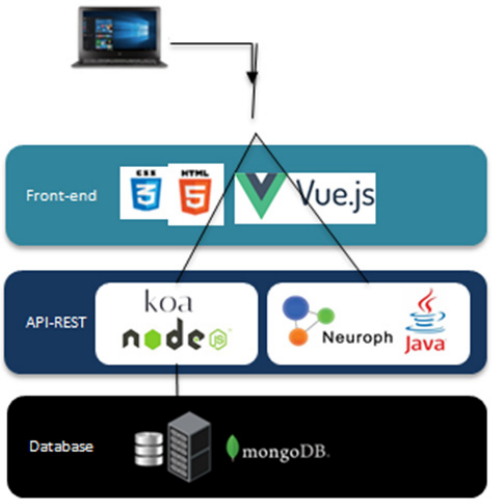

Fig. 4. General architecture of the application

V. RESULTS AND DISCUSSIONS

In this section the results of the experiments are shown comparing 3 architectures for the neural network.

We conducted the experiment using data from the 2016 Peruvian National Penitentiary Census, which consists of 14,000 records. The dataset was partitioned into two sets: the first was assigned to training 70% and to the tests 30%.

In addition, the training of the networks required normalizing the data, using the MinMax method:

$$z_i = \frac{x_i - \min(x)}{\max(x) - \min(x)}$$

Where $x = (x_1, \ldots, x_n)$ and z_i is the i-th normalized data.

The first proposed architecture was a multilayer network with 24 input neurons, 11 neurons in the hidden layer and 19 output neurons. The network trained for 500 epochs, with a learning factor of 0.2 and a momentum of 0.7, the mean square error obtained was 0.312. In the testing phase, the network reached an average square error of 0.034.

The second proposed architecture consists of a multilayer network with 24, 21 in the hidden layer and 19 output neurons. The network trained for 1000 epochs, with a learning factor of 0.3 and a momentum of 0.8, the mean square error obtained was 0.302. In the testing phase, the network reached an average square error of 0.035.

The third proposed architecture consists of a multilayer network with 24 neurons, 22 neurons in the first hidden layer, 20 neurons in the second hidden layer and 19 output neurons. The network trained for 1000 epochs, with a learning factor of 0.3 and a momentum of 0.8, the mean square error obtained was 0.278. In the testing phase, the network reached an average square error of 0.039. Finally, this network is chosen as the most suitable due to its low mean square error.

In this work, 3 architectural proposals have been evaluated for a multilayer perceptron trained with the backpropagation algorithm. The chosen proposal corresponds to an architecture with 22 (21 plus bias or bias) neurons in the first hidden layer, 20 (19 plus the bias or bias) neurons in the second hidden layer, given that its quadratic error (0.278) was the minor of the three during the training stage, and his quadratic error in the testing phase, gives him an accuracy of 96.03%.

In the research [11] they improve the crime classification method; they obtained an accuracy of 65.94% with Backpropagation and an accuracy of 94.0822% with the Naive Bayes algorithm. Comparing with our work, we selected the best Backpropagation architecture, achieving an accuracy of 96.03%

In the state-of-the-art chapter, it was noted that most of the research uses clustering and data mining techniques ([12], [13], [17], [18]). However, there are also proposals where neural networks are used with different classification algorithms (Naive Bayes [11] and backpropagation [11]) and even genetic algorithms, as in [13]. In this work we continue investigating that backpropagation Neural Networks allows classifying the types of crime that people could commit.

In research [13], a security system by improving the K-means algorithm was designed, in the experiment they achieved an average accuracy of 91.3%. In our work, 3 neural network architectures were compared to observe which of the architectures obtains the lowest error and the best accuracy.

In [12], they manage to classify the crimes grouped according to the occurrence and frequency, they used data mining techniques to determine patterns, for clustering they used K-means, in the classification they achieve 85% accuracy, finally they optimize with genetic algorithms achieving an optimization of up to 91.64% accuracy. Comparing with this work, Backpropagation Neural Networks have been used to predict the type of crime that a person can commit, achieving an accuracy of 96.03%.

It should be noted that in research [11], [14], [17] and [18] for the experimentation they also used real data that came from government entities. Comparing with our work, 14,000 records have been used, exceeding the number of records that allowed validating the architecture, the data was collected by the Censo Nacional Penitenciario carried out by government entity (INEI).

VI. CONCLUSIONS

In this research we have designed three neural network architectures to find the one that best predicts crime. We conclude that the neural network architecture with 24 input neurons, 21 neurons in the first hidden layer, 21 neurons in the second hidden layer and 19 neurons in the output layer is the most recommended for predicting crimes with the mean square error obtained was 0.278. We have also implemented a web application as a tool for the institutions that administer and punish crimes.

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